CARLO GAVAZZI SPACE SpA

0 CERN MIT L3 A&C/AMS

AMS02-PDS

NON CONFORMANCE REPORT

1 NCR ref: Doc.N°: NCR-PDS-CGS-C-139
Rev.: 1 Date: 1/09/2009
Page 1 of 4 attach: A, B, C

2 NCR Title: Unwanted SIDE A PB2-3 switch OFF during HOT temperature TV cycling

IDENTIFICATION

3 Supplier	4 Purchase Order N°.	5 Model	6 Subsystem	7 Procedure/Work item N°
CGS	N.A.	PFM	N.A.	N.A.

8 NC ITEM Identification	9 Drawing N°. Rev.	10 P.N. / C.I. N°	11 Serial N°
PB2 Board Module Assy	11-AMS02PDS-700.00 /	11-AMS02PDS-700.00	04

12 Next Higher Unit Id.	13 Drawing N°. Rev.	14 P.N. / C.I. N°	15 Serial N°
AMS02 Power Distribution System Assembly	10-AMS02PDS-000.00 /	10-AMS02PDS-000.00 / PDS18	FM01

DESCRIPTION

16 NON CONFORMANCE Detected During:
RECEIVING INSP. [ ] MANUFACT [ ] ASSEMBLY/INTEGRATION [ ] FINAL INSPECTION [ ] TEST [X] OTHER........ [ ]

17 Initiator, Dept., Date, Signature R. Grossi, DT/PE, 1/09/2009 (signature)

18 Description of NON CONFORMANCE

During execution of routine electrical verification during TV cycle, side A PB2 -3 has stopped working.
At the moment of malfunction, test conditions were:

- 5th cycle (hot temperature)
- Side A ON and side B OFF
- Nominal load (see ¶10.3.1.8.1 of procedure PDS-PR-CGS-006 Is.2) and minimum input voltage = 113V

19 Requirements violated

¶4.1.4.1 of AMS-RQ-CGS-002 Is.1 *"Power Distribution System (PDS) Specifications"*

INTERNAL NRB DISPOSITIONS

20 INTERNAL NRB Dispositions:

See following pages

21 Verifications

22 Suspected cause of NC: HANDLING [ ] TRANSPORTATION [ ] TEST EQUIPMENT [ ] TOOLS [ ] SW [ ] DESIGN [X]
OPERATOR/PROCEDURE ERROR [ ] PART [ ] MATERIAL [ ] PROCESS [ ] TEST [ ] OTHER....... [ ]

23 Classification MINOR [ ] MAJOR [X]

Corrective/Preventive Actions: 24

25 REQUEST FOR WAIVER YES [X] NO [ ] N° PDS-WV-CGS-005 Is.1

26 Analysis Required YES [ ] NO [ ] N°

27 Other related documents:

Department:	28 P.A.	29 Syst. Engineering	30	30 P.M.	31 C.C.
Name:	Francini E.	Alia S.		Olivier M.	Cinquepalmi C.
Signature:	(signature)	(signature)		(signature)	(signature)
Date:	01/09/09	01/9/09		01/09/2009	01/09/2009

CUSTOMER/HIGHER LEVEL CONTRACTOR NRB DISPOSITIONS

32 CUSTOMER/HIGHER LEVEL CONTRACTOR NRB Dispositions (Class Major Only):

21 Verifications

33 Finally determined Cause of NC

34 Corrective/Preventive Actions:

35 Customer/HLContractor Approval:

Department:	AMS	ASI	ASI
Name:	Michee (Capell)	Fausto Marchetti	E. Russo
Signature:	(signature)	(signature)	(signature)
Date:	18 Sep 09	21/Sep. 09	21/Sep 09

36 CLOSE OUT CERTIFICATION

CGS PA/QA: E. FRANCINI (signature) 29/09/09

PA/QA Stamp: CQ 2 C.G.S.

37 CONTINUATION SHEET

☐ SUSPECTED CAUSE OF NC ☐ INTERNAL NRB DISPOSITION ☒ DESCRIPTION OF NC

☐ FINALLY DETECTED CAUSE ☐ CUSTOMER NRB DISPOSITION ☐ CORRECT/PREVENT. ACTIONS

☐ REQUIREMENTS VIOLATED

21 Verifications

FAILURE DESCRIPTION

The recorded malfunction has been:

- Impossibility to send command /receive significant telemetry from side A PB2 -3 (all digital statuses set to 1, all analog telemetries to the minimum range – i.e. 0 or few units digital counts)
- Output voltage for all outlets of side A ESEM3A-3 (which is powered by side A PB2 -3) =0V and subsequent impossibility to power external loads

FAILURE RECOVERY

The execution of a 120V inlet power switch cycle (ON-> OFF-> ON) has been performed and, as a result, nominal PDS functionality restored.

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37 CONTINUATION SHEET

SUSPECTED CAUSE OF NC	X INTERNAL NRB DISPOSITION	DESCRIPTION OF NC
FINALLY DETECTED CAUSE	CUSTOMER NRB DISPOSITION	CORRECT/PREVENT. ACTIONS
REQUIREMENTS VIOLATED		

	21 Verifications
1. Perform an analysis of the malfunction to identify possible root causes	1. OK 1/9/09 The only failure scenario compatible with such an event is the switch OFF of the auxiliary DC/DC mounted on the board, which supplies all PB2 internal circuitry. As protection intervention is latched, the only way to recover nominal board (and therefore PDS) functionality is to remove PDS internal bus power (nominal voltage 15V). PDS internal bus power is provided by the two hot redundant converters of ESEM1A board that can not be commanded; therefore a 120V inlet power switch cycle (ON-> OFF-> ON) has to be performed.
2. Perform additional tests to confirm analysis results and characterize operative condition that influence failure occurrence	2. OK 1/9/09 - Failure is repetitive provided that test conditions are the same of first recorded event (i.e. nominal load, minimum input voltage of 113V and TRP above 53°) and adequate time is allowed to stabilize PDS internal temperatures - After failure occurrence, unit functionality is restored by input bus ON-> OFF-> ON cycle and this status is maintained for some minutes before new failure occurrence even though unit working conditions are set to be the same as before first failure - Modification of test conditions (namely, TRP temperature decrease or input voltage increase) prevents failure appearance - No similar malfunction has been recorded on side B boards, though the same operative and environmental conditions have been applied also to these boards

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37 CONTINUATION SHEET

☐ SUSPECTED CAUSE OF NC ☒ INTERNAL NRB DISPOSITION ☐ DESCRIPTION OF NC
☐ FINALLY DETECTED CAUSE ☐ CUSTOMER NRB DISPOSITION ☐ CORRECT/PREVENT. ACTIONS
☐ REQUIREMENTS VIOLATED

	21 Verifications
3. Set-up a teleconf with AMS collaboration to inform about failure and analysis results	3. OK 2/9/09
3.1 Continue with test (raising input voltage at 114V minimum if necessary)	3.1 see Annex A
3.2 Summarise test results performed outside TVT Functional test procedure to clarify which operative solutions (e.g. load switch OFF or use of redundant board) can be found to prevent failure occurrence	3.2 SEE ANNEX B 23/09/09
3.3 Perform an update of the thermal analysis, based on power dissipation data measured during TVT –that are lower than previously estimated ones-, to evaluate new PDS WC baseplate temperature	3.3 SEE ANNEX C 23/09/09
4. ISSUE REQUEST FOR WAIVER	4. CLOSED 23/09/09

ANNEX A TO NCR-PDS-CGS-C-139
2 PAGES

Roberto Grossi

Da: Mike Capell [Michael.Capell@cern.ch]
Inviato: mercoledì 2 settembre 2009 12.45
A: rgrossi@cgspace.it
Cc: molivier@cgspace.it; plorenzi@cgspace.it; salia@cgspace.it
Oggetto: RE: undesired protection intervention of the Auxiliary DC/DC during TVTB

Categorie: CERN SpamKiller Note: -50

Thanks Roberto - this is what I thought (that E3A#3 is not the most loaded) but it is easier to see the numbers. So let me see if I understand the situation:

At +53C on the TRP (somewhere on the baseplate) and 113VDC input the auxiliary DC-DC on E3A #3 overheats and trips. After this no communication with the module is possible and the only recovery possible is to cycle the input power.
At +50C TRP or at 114VDC input this doesn't happen. This does not happen for the other seven E3A's. This did not appear in non-vacuum thermal testing.

Is that all correct?

My suggestion is just to continue the test at minimum voltage 114VDC input on the A side.
I don't think this is worth opening the box and finding the slightly out of tolerance resistor (or whatever) that is causing the problem.

-Mike.

Mike Capell +41 22 767 4706

-----Original Message-----
From: rgrossi@cgspace.it [mailto:rgrossi@cgspace.it]
Sent: Wednesday, 02 September 2009 12:33
To: Mike Capell
Cc: molivier@cgspace.it; plorenzi@cgspace.it; rgrossi@cgspace.it; salia@cgspace.it
Subject: RE: undesired protection intervention of the Auxiliary DC/DC during TVTB

Dear Mike,

when we refer to nominal condition, we implicitly point to Step 4 in the spreadsheet you and Sergio set-up together in the past years for PDS power budget.
In any case, in the attached Excel file yo will find the detils: basically all nominal outlets are ON, all redundant are OFF.

In addition also Outlet 12 of E3B (i.e. CCEB) is also ON (about 400W), but this does not matter as it is at 120V...

Bye, Roberto

> What was the total load on PB2 #3?
> What is the load on the other PB2's?
>
> Call anytime.
>
> -Mike.
>
> ---
> Mike Capell +41 22 767 4706
> ---
>
>
> -----Original Message-----
> From: Massimiliano Olivier [mailto:molivier@cgspace.it]

> Sent: Wednesday, 02 September 2009 11:12
> To: Mike Capell; Xudong Cai
> Cc: plorenzi@cgspace.it; rgrossi@cgspace.it; salia@cgspace.it
> Subject: PDS: undesired protection intervention of the Auxiliary DC/DC
> during TVTB
>
> Dear Xudong , please be so kind to forward this message to Mike:
>
> Dear Mike,
>
> during thermal vacuum testing, a malfunction of one PB2 board (namely #3
> of
> side A) has been recorded during HOT plateau, 53°C -0°C/+3°C (based on a
> Temperature range Operative HOT for PDS of +48°C with on top a 5°C proto
> qualification margin), with unit loaded in nominal configuration and
> supplied with minimum input voltage of 113V.
>
> The malfunction results in no power present at relevant 28V outlets and
> impossibility to receive telemetries / sending command to the board.
> To recover the situation, it has been necessary to switch OFF / ON the
> input power supply.
> No malfunctions have been recorded in the same condition when side B of
> PDS is operated.
>
> Additional investigations have shown that such malfunction can be
> reproduced provided that the same input voltage / environment temperature
> / load conditions are present.
>
> In order to try and limit the occurence of this phenomenon, some further
> tests have been conducted and preliminary data show that eitheir reducing
> TRP temperature or slightly incresing applied voltage results in correct
> board (and therefore PDS) operation.
> Specifically, correct operation was obtained with TRP stabilized at 50°C
> (instead of 53°C) with nominal load and minimum input voltage of 113V;
> alternatively, PDS operates well at 53°C with nominal load in case that
> input voltage is 114V (instead of 113V).
> Unfortunately, due to long time required to change operating conditions
> (thermal chamer inertia is extremely significant) and to wait for
> stabilization after modification, only a few attempts could be carried
> out.
>
> Some additional tests have been performed to find the possible root cause
> for such a malfunction, which has been identified in the undesired
> protection intervention of the Auxiliary DC/DC mounted on the board.
>
> We think a viable solution with no impact on the PDS test schedule could
> be
> found evaluating the operative modes of AMS with you.
> We propose to urgently discuss this topic into details by phone as soon as
> you have time to read this e-mail and decide how to proceed with the test.
>
> Best Regards
>
> Massimiliano.
>
>
>
>

Introduction

Nominal configuration identification

After the first cycle, used for Full Functional characterisation at HOT=+53° -0/+3°C and COLD = -25° -3/+0°C temperatures, the following PDS unit configurations have been adopted for HOT and COLD temperature stabilisation:

HOT temperature

1) All PB2 boards switched ON
2) All ESEM3-A Nominal outlets switched ON (see Tab. 1)
3) Only outlet 12 of ESEM3-B switched ON (no heaters load)

Board	Out. #1 Load [A]	Out. #2 Load [A]	Out. #3 Load [A]	Out. #4 Load [A]	Out. #5 Load [A]	Out. #6 Load [A]	Out. #7 Load [A]	Out. #8 Load [A]
ESEM3A-1	3.0	3.0	1.8	1.5	1.2	0.0	3.0	0.0
ESEM3A-2	3.5	2.9	3.0	1.4	1.8	1.6	1.5	0.7
ESEM3A-3	2.9	2.9	3.4	0.0	0.0	0.0	0.0	2.6
ESEM3A-4	0.0	0.0	0.0	0.0	1.6	1.5	3.0	4.8

Tab. 1: Nominal load configuration for HOT temperature stabilization[1]

COLD temperature

1) Only PB2 boards #1 and #4 switched ON (default ON boards)
2) All ESEM3-A switched OFF (see ***Tab. 2***), except for outlet 3 of ESEM3-A#1 and outlet 1 of ESEM3-A#4 (that are connected to JPD loads)
3) Outlets 1, 2, 3, 6 of ESEM3-B switched ON (default ON heaters load)

Board	Out. #1 Load [A]	Out. #2 Load [A]	Out. #3 Load [A]	Out. #4 Load [A]	Out. #5 Load [A]	Out. #6 Load [A]	Out. #7 Load [A]	Out. #8 Load [A]
ESEM3A-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ESEM3A-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ESEM3A-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ESEM3A-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Tab. 2: Nominal load configuration for COLD temperature stabilization[2]

[1] This is the nominal configuration used for power budget spreadsheet computation (step 4)
[2] These are the default ON state outlets, without any load because at -25°C the series thermostats will prevent PDS loading

Routine electrical checks during TV cycles

During all temperature cycling, the following test have been performed continuously to monitor correct unit functionality:

"Periodic" checks (every hour)

1) All boards and all outlets switched ON/OFF/ON to check their commandability, using dedicated commands on PDS test GUI SW interface, by either side A or side B CAN bus board
2) Verification of all board statuses, relevant temperatures and reference voltage values, using dedicated commands on PDS test GUI SW interface, by both CAN bus boards (see applicable steps of ¶10.3.1.2.3 and ¶10.3.1.2.4 -for side A- and ¶10.3.2.2.3 and ¶10.3.2.2.4 -for side B- of "*AMS02-PDS PFM FULL FUNCTIONAL TEST PROCEDURE*" **PDS-PR-CGS-006 Is. 2**)
3) Snapshot of PDS test GUI SW interface, showing ESEM1-A analogue tlm. and digital statuses, input stage tlm. and overall OK/NOK statuses / temperature telemetry for all boards
4) Input bus voltage variation in the nominal 113-126V, acting on external power supply

"Cyclic" checks (once every plateau, either HOT or COLD, at the end of stabilization phase)

5) PDS unit dissipation (see ¶10.3.1.8 -for side A- and ¶10.3.2.8 -for side B- of "*AMS02-PDS PFM FULL FUNCTIONAL TEST PROCEDURE*" **PDS-PR-CGS-006 Is. 2**)
6) Outlet overcurrent protection tripping (see relevant steps of ¶10.3.1.5.4, ¶10.3.1.5.6, ¶10.3.1.5.8, ¶10.3.1.5.10, ¶10.3.1.5.11 -for side A- and ¶10.3.2.5.4, ¶10.3.2.5.6, ¶10.3.2.5.8, ¶10.3.2.5.10, ¶10.3.2.5.11 -for side B- of "*AMS02-PDS PFM REDUCED FUNCTIONAL TEST PROCEDURE*" **PDS-PR-CGS-020 Is. 1**)

First failure occurrence

During 5th cycle HOT plateau, with Side A of PDS unit switched ON, PB2-3 board has been found in OFF condition while performing unit dissipation test at 113V input (ref. ¶10.3.1.8.2 of "*AMS02-PDS PFM FULL FUNCTIONAL TEST PROCEDURE*" **PDS-PR-CGS-006 Is. 2**).
Symptoms of the malfunction were (see *Fig. 1*):

- Absence of 28V output voltage at all outlets of ESEM3A-3 board (which is powered by PB2-3)
- All board analogue telemetries to low range (around 0V -equivalent to few digital counts)
- All board digital statuses to "High" level (which results in non consistent indications, e.g. board is commanded OFF – though no such command has been sent – but status is ON)

Above described situation is only compatible with complete switch OFF of the aux. DC/DC converter mounted on PB2; in this case, all board internal circuits are not supplied (and therefore not functional) and, as a result, no analogue telemetry is available (0V is read by CAN bus board mounted A/D converter also for "Analog Ref. 2.0V" which is directly related to aux. DC/DC supply voltage) while the pull-up resistor, mounted on CAN bus at digital status line, forces an high state (which is read and interpreted as "NOK" by CAN bus board).
As failure of aux. DC/DC converter board is latched, the only way to restore nominal functionality is to remove aux. DC/DC inlet power; a 120V ON/OFF/ON cycle has to be performed.

After a 120V ON/OFF/ON cycle, unit functionality has been restored and nominal configuration (see ***Tab. 1***) could be commanded. Then input voltage has been set to nominal voltage for continuation of functional verifications.

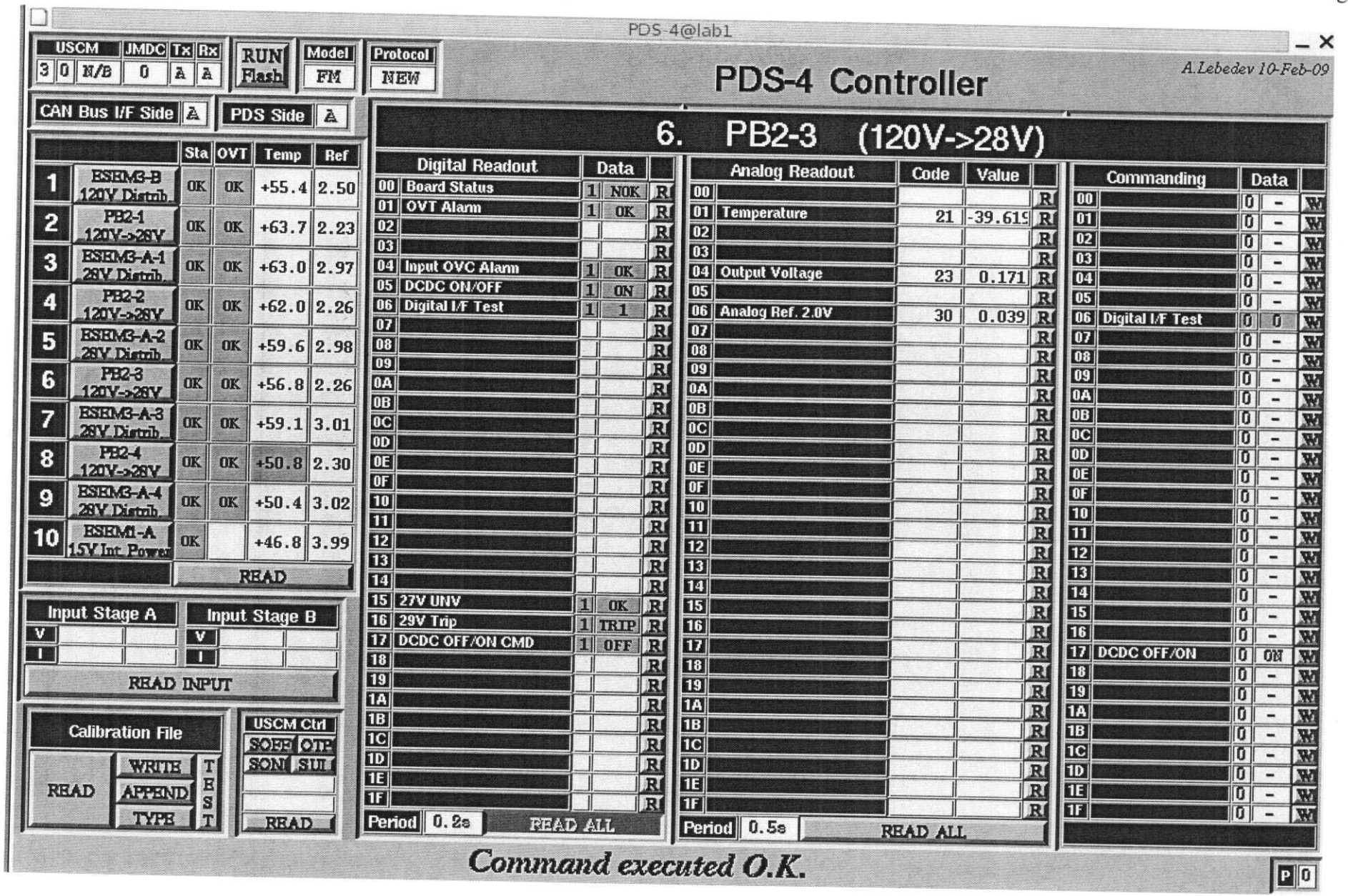


Fig. 1: PDS GUI screenshot after PB2-3 failure occurrence

Additional investigations

After conclusion of routine electrical checks, a dedicated investigation has been started to better identify recorded malfunction in terms of:

- Occurrence
- Relationship with test conditions

In the following paragraphs, the list of performed activity is reported in a chronological order; then, a summary of the derived conclusions is also provided.

Failure repeatability

h.14:45÷15:45 01/09/09: with TRP temperature at 53.9°C, PDS has been left at 113V in nominal condition and failure could be reproduced. It has been noted that after every PB2-3 not commanded switch OFF:

- it is always possible to restore full PDS functionality by means of 120V ON/OFF/ON cycle, without necessity of changing operating conditions (i.e. unit can work with the same electrical input and output voltages and currents that were present before failure)
- some minutes of unit operation are necessary before new failure occurrence.

Apparently, board internal temperatures have to reach again a critical region to allow malfunction occurrence; no significant variation of overall PDS temperature, monitored at TRP level, can be appreciated due to much higher unit thermal inertia.

Effect of input voltage variations

h.15:45÷16:00 01/09/09: with TRP temperature set at 53.9°C, input voltage has been raised at 114V; no unwanted switch OFF of PB2-3 has been recorded
h.16:00 01/09/09: with TRP temperature set at 53.9°C, input voltage waveform has been monitored to verify presence of significant undershoot in the 120V->113V transition (see *Fig. 2*). Recorded waveform shows a smooth decrease of input voltage; no electrical circuit related causes (e.g. undervoltage protection intervention) for malfunction can be derived from analysis of EGSE power supply provided voltage.[3]

Effect of TRP temperature

h.16:00 01/09/09: cold plate temperature adjusted to have a TRP temperature set at about 50.3°C; during temperature decrease some sporadic switch off have been recorded with input voltage set at 113V
h.20:00 01/09/09: after stabilisation phase with TRP temperature set at 50.3°C, no malfunctions have been recorded with input voltage set at 113V both in a static condition and during 10 variations from 126.5V (max. nominal voltage) to 113V (min. nominal voltage) and vice versa.
Remark: voltage has been measured at unit input level – by means of J300 test points; EGSE power supply was set respectively to 127.9V and 114.7V

Based on above test results, it has been hypothesised that input voltage has no direct influence on failure occurrence; rather presence of a low input voltage results in poorer PB2 converter efficiency[4] that induces slightly higher PB2 internal temperature.

---

[3] It is further noted that internal 120V bus – downstream PDS input filter – is even much more stable, due to big size input capacitor
[4] This has been confirmed by power dissipation measurement at 113V w.r.t. 120V or 126V

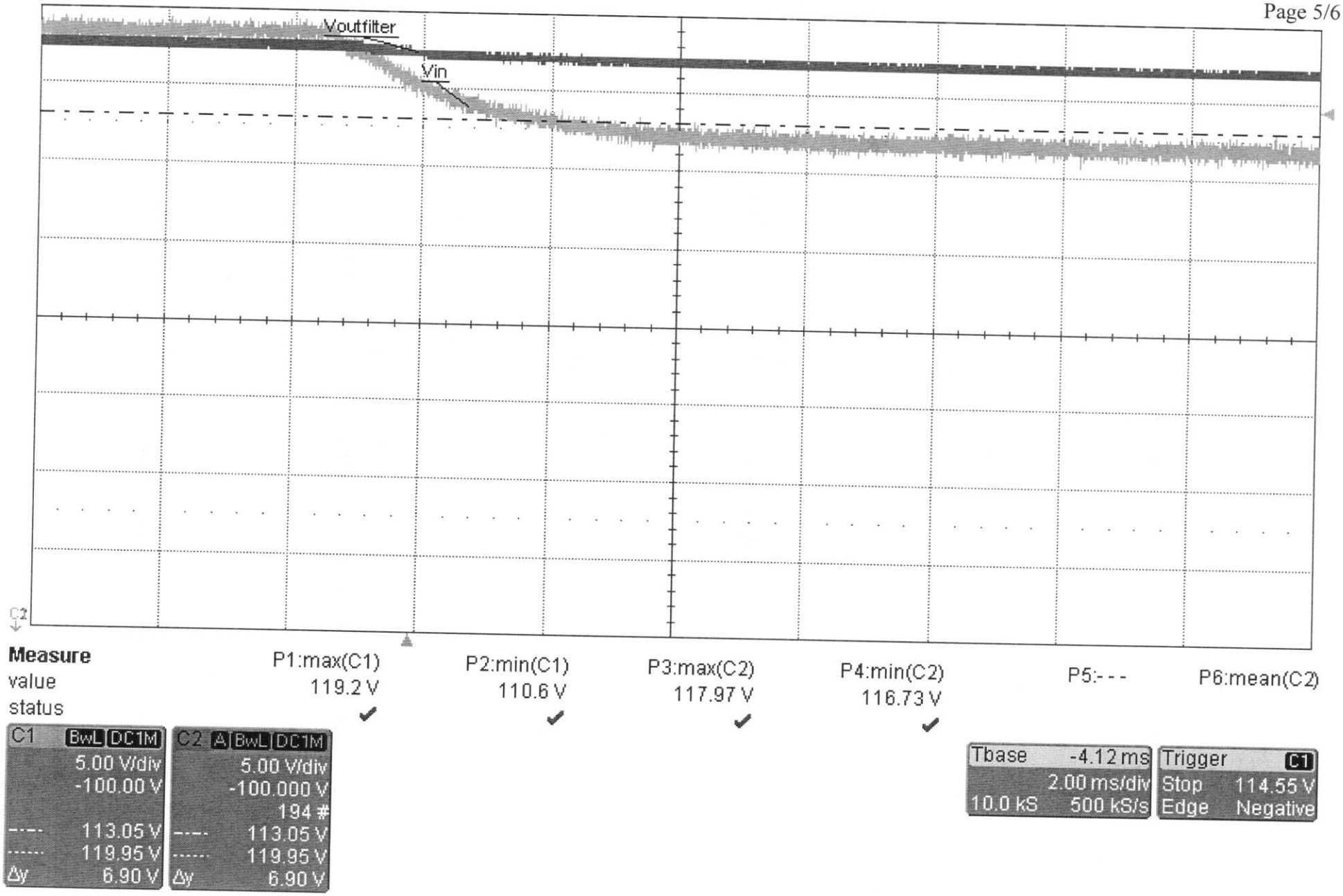


Fig. 2: PDS GUI screenshot after PB2-3 failure occurrence

To proof this hypothesis, it has been decided to further decrease input voltage below 113V (without tripping input undervoltage protections), while keeping constant TRP temperature at 50.3°C and nominal loads of ***Tab. 1***.

h.20:30 01/09/09: Starting with EGSE power supply voltage set on of 114.7V (equivalent to 113V at PDS input), 0.5V downward steps have been applied every about 30 seconds – to allow verification of correct unit functionality in new operating condition.
First failure occurrence has been recorded at 111.7V –set on power supply (equivalent to 109.4V read with multimeter at PDS input) after about 3 minutes from test start
Following power inlet ON/OFF/ON cycle[5], the descent has been continued with smaller steps of 200mV each.
Second failure has been recorded at 110.3V –set on power supply (equivalent to 108.1V read with multimeter at PDS input) after about 4 minutes from previous failure.
Following power inlet ON/OFF/ON cycle[5], the descent has been continued with same steps of 200mV each as before.
Third failure has been recorded at 107.5V –set on power supply (equivalent to 105.5V read with multimeter at PDS input) after about 5 minutes from previous failure.
Following power inlet ON/OFF/ON cycle[5], no further decrement of input voltage has been applied and a fourth failure recorded after about 3 minutes from previous one.
PDS has been switched OFF and ON again to clear failure effects, input voltage raised in the nominal range and temperature cycling continued as foreseen by the procedure with the 5th cold plateau.

Conclusive summary

The tests which have been performed after first PB2-3 failure detection allow to:

- identify operative condition (input voltage and/or temperature) compatible with nominal PDS functionality.
- clarify that input voltage is not the **direct** cause of recorded malfunction
- hypothesise as root cause for failure the temperature sensitivity of one component in the input overcurrent protection of the aux. DC/DC of PB2-3 (that is the only circuit which can completely switch OFF converter itself)

[5] PDS functionality has been restored and unit loaded with ***Tab. 1*** nominal loads

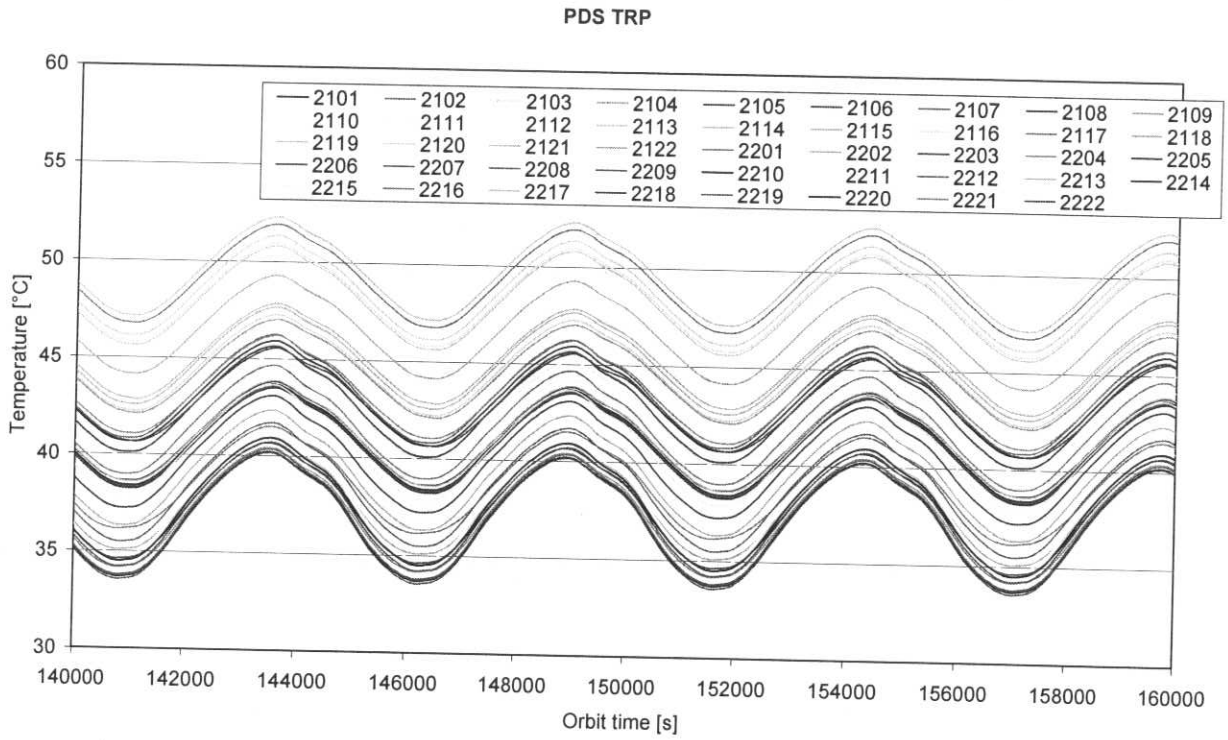
Author: Paolo Ruzza

PDS: Evaluation of maximum temperature with updated PDS dissipation

Introduction

Thermal dissipation of PDS has been updated, according to data collected during the qualification test. Actual thermal dissipation obtained during testing is globally 310W vs the former 365W used for the design analyses.

From the previous analyses reported in AMSTCS-TN-CGS-004 MAIN AND TRACKER RADIATOR THERMAL ANALYSIS REPORT Tmax at TRP was 52.3°C

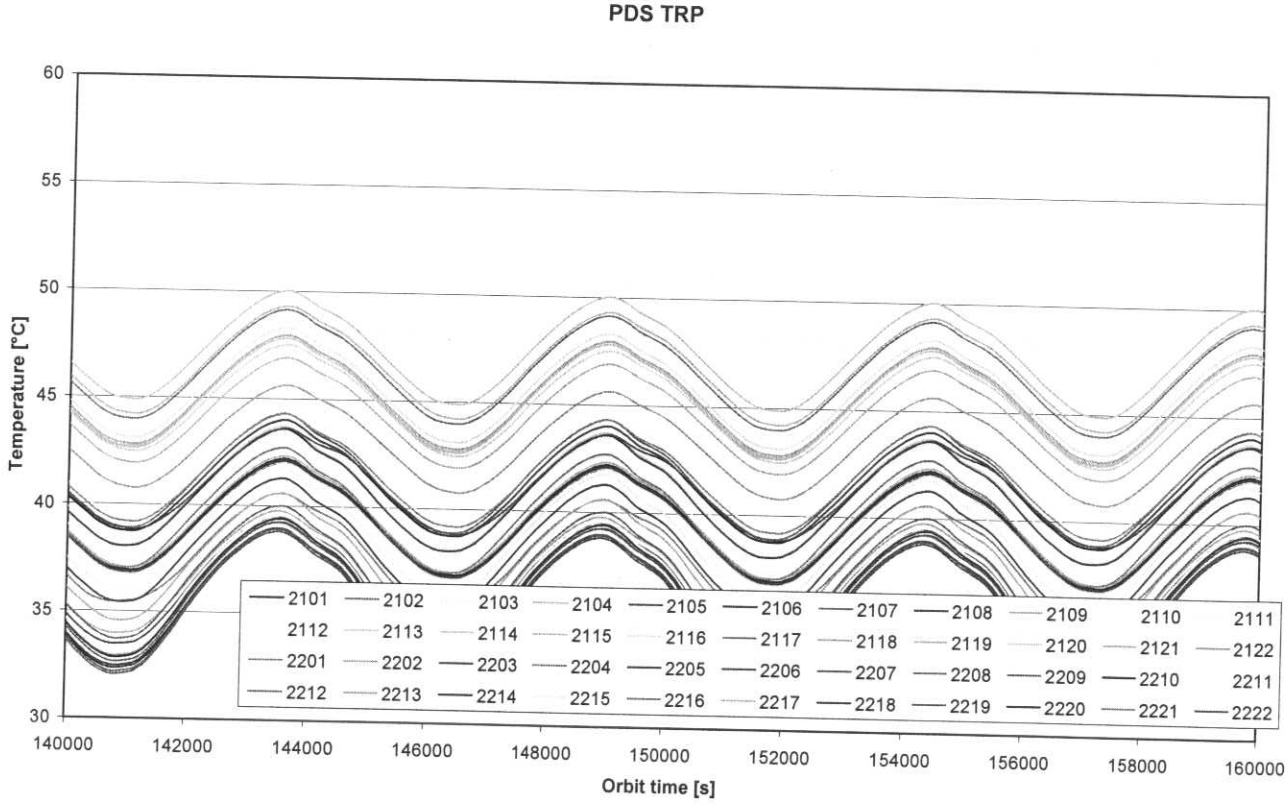


Power on each board has been updated to globally 310W distributed on two different nodes:

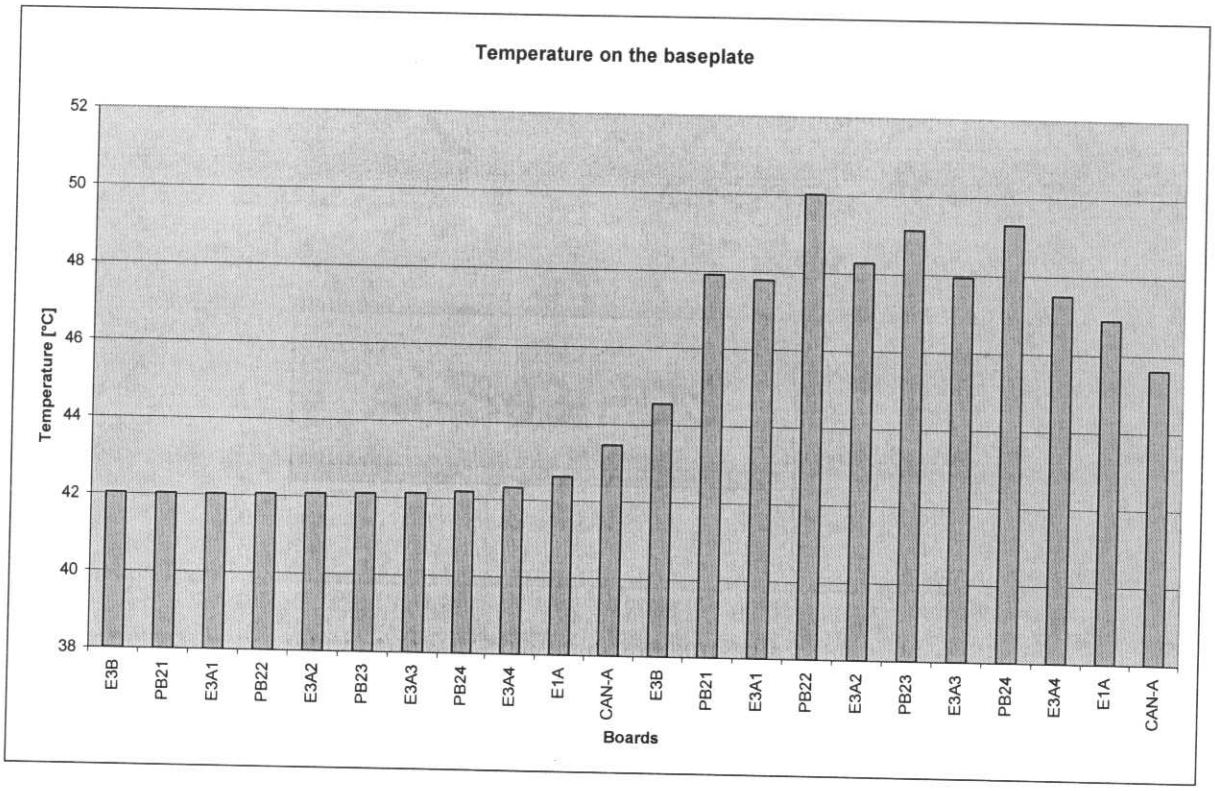
		Node	New Power	Node	New Power
BUS A	E3B	5001	0.00	5301	0.00
	PB21	5002	0.00	5302	0.00
	E3A1	5003	0.00	5303	0.00
	PB22	5004	0.00	5304	0.00
	E3A2	5005	0.00	5305	0.00
	PB23	5006	0.00	5306	0.00
	E3A3	5007	0.00	5307	0.00
	PB24	5008	0.00	5308	0.00
	E3A4	5009	0.00	5309	0.00
	E1A	5010	0.00	5310	0.00
	CAN-A	5011	0.00	5311	6.31
BUS B	E3B	5012	1.21	5312	2.12
	PB21	5013	3.09	5313	41.16
	E3A1	5014	2.35	5314	12.18
	PB22	5015	2.88	5315	54.47
	E3A2	5016	2.50	5316	14.28
	PB23	5017	2.59	5317	40.06
	E3A3	5018	2.20	5318	11.73
	PB24	5019	2.84	5319	38.83
	E3A4	5020	2.41	5320	11.26
	E1A	5021	0.00	5321	17.93
	CAN-A	5022	0.00	5322	6.37

Results

The New Tmax at PDS TRP is 50.0°C on node 2115



Temperature spatial distribution on the baseplate, board side (picked @ time with the higher temperature):



The maximum instantaneous temperature calculated in the worst hot case with the maximum PDS dissipation of 310W is 50°C, and is below the maximum tested temperature of 50.3°C to which the PDS unit is able to continuously operate with a 113 V input (see annex B).

Considering the margins taken in the worst hot case definition, the margin attained is sufficient to guarantee the correct operation of PDS on orbit without operational restrictions in nominal configuration.